CLINICAL EVALUATION OF BITE FORCE IN CHILDREN AND ADULTS WITH NORMAL OCCLUSION AND COMPARISON OF NORMAL ADULT BITE FORCE IN INDIVIDUALS WITH DIFFERENT MALOCCLUSIONS

A Dissertation Submitted

in partial fulfillment of the requirements

for the degree of

MASTER OF DENTAL SURGERY

BRANCH – V

ORTHODONTICS

THE TAMIL NADU Dr.M.G.R. MEDICAL UNIVERSITY

CHENNAI -600 032

2005 – 2008

CERTIFICATE

This is to certify that **Dr.P.S.HARITHA**, Post Graduate student (2005 – 2008) in the Department of Orthodontics, Tamil Nadu Government Dental College and Hospital, Chennai – 600 003, has done this dissertation titled **"CLINICAL EVALUATION OF BITE FORCE IN CHILDREN AND ADULTS WITH NORMAL OCCLUSION AND COMPARISON OF NORMAL ADULT BITE FORCE IN INDIVIDUALS WITH DIFFERENT TYPES OF MALOCCLUSIONS"** under our direct guidance and supervision in partial fulfillment of the regulations laid down by **The Tamil Nadu Dr.M.G.R. Medical University**, **Chennai -600032** for **M.D.S.** (Branch–V) **Orthodontics** (Part II) degree examination.

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ACKNOWLEDGMENT

I consider it my utmost privilege and a great honor to express my deep sense of gratitude to my respected Professor **Dr.W.S.MANJULA, M.D.S.,** Head of the Department, Department of Orthodontics and Dentofacial orthopedics,, Tamilnadu Government Dental College and Hospital, Chennai-3, for her excellent and valuable guidance throughout the study and for the untiring spirit displayed by her during the hours of discussion of results.

I express my heartfelt gratitude to **Dr.C.KARUNANITHI, M.D.S.,** Professor, Department of Orthodontics, Tamilnadu Government Dental College and Hospital, Chennai-3, for helping me with his valuable suggestions, words of constructive criticism and valuable guidance in making this work possible.

I wish to express my deep sense of gratitude to **Dr.M.C.SAINATH, M.D.S.,** Professor, Department of Orthodontics, Tamilnadu Government Dental College and Hospital, Chennai-3 for providing precious guidance, support and the constant encouragement throughout the entire duration of the study.

My sincere thanks to **Dr.K.S.G.A.NASSER,M.D.S.,**Principal, Tamil Nadu Government Dental College and Hospital, Chennai – 600 003, for his kind permission and encouragement.

I am bound to acknowledge the constant support and motivation extended by my Assistant Professors, **Dr.S.Premkumar,M.D.S, and Dr.J. Nagalakshmi, M.D.S.** throughout the study.

I thank Professor, **Dr. S.Jayachandran**,**M.D.S**, Head of the department, Oral medicine and Radiology and radiologist for helping me in taking lateral cephalograms in Tamilnadu government dental college and hospital, Chennai.

I express my gratitude to **Mrs. Jennifer**,M.S.C Statistics, lecturer in saveetha dental college and hospital for doing the statistical analyses.

I seek the blessings of the Almighty God without whose benevolence this study wouldn't have been possible.

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Introduction

INTRODUCTION

The practice of orthodontics involves the understanding and application of both biomechanical principles and the underlying biological adaptation which enables a clinician to achieve a desired outcome. Treatment planning is based on both biomechanical considerations and awareness of the craniofacial muscular environment. The muscles of the maxilla and mandible are of paramount importance in the etiology and active treatment of malocclusions and jaw deformities and also for the stability of such treatment.

It is a well known fact that there exists a relationship between form and function. Masseter, Temporalis, Medial pterygoid and Lateral pterygoid forms the masticatory muscles. The function and form of mandibular muscles correlate with the morphologic features of the craniomandibular apparatus to which the muscles are related. Studies done by Ingervall and Helkimo[26], Kiliaridis[30,31] suggests that adults with weak muscles have a greater variation in facial morphology than those with stronger muscles which supports the theory that form of the face depends on the strength of the mandibular muscles.

Evaluation of masticatory muscle function occupies an important role in diagnosis and treatment planning. The function of masticatory muscles is an important factor influencing the dentofacial growth. The masticatory muscles also play a major role in the treatment of skeletal discrepancies with functional appliances. The interaction between size and function of the masticatory muscle and craniofacial morphology is well proven.

Masticatory muscle strength can be evaluated by different methods and is influenced by many variables. Maximum bite force is a useful indicator of the functional state of the masticatory system and the loading of teeth.

Bite force can be defined as the forces applied by the masticatory muscles in dental occlusion[2]. Bite force is the result of the coordination between different components of the masticatory system which includes muscles, bones and teeth. Bite force results from the action of the jaw elevator muscles which is determined by the central nervous system and feedback from muscle spindles, mechanoreceptors and nociceptors modified by the craniomandibular biomechanics[2]. The model proposed by Throckmorton et al[82] explains that bite force reflects the geometry of the jaws lever system. The adductor Muscles of the mandible have a greater mechanical advantage when the ramus is more vertical and gonial angle is small. As the gonial angle increases, the mechanical advantage of the muscles is lessened resulting in less force perpendicular to the occlusal plane.

The factors which controls the magnitude of bite force are jaw muscle size which includes the cross sectional area and thickness (Van Spronsen et al[86,87]) , fiber type composition (Ringqvist[65,66]), sarcomere length (Van Eijden[92,93] and Raadsheer[61]) and level of muscle activation(Van Eijden et al[93]).

Malocclusions are often associated with altered bite force. Children with unilateral posterior cross bites and adults with anterior open bite have been reported to have lower maximum bite force. Proffit and Fields[57] found strong bite forces in brachyfacial individuals and weak bite forces in dolicofacial individuals. This finding supports the theory that the form of the face partly depends on the strength of the mandibular muscles. Bite force is well correlated to facial morphology. A significant correlation exists between mandibular plane angle, ratio of posterior to anterior facial height, lower anterior facial height.

Assessment of bite force gives a clue to the orthodontist regarding the facial morphology and the type of mechanics to be used. It is also helpful in the diagnosis of disturbances of the stomatognathic system.

There are various methods to evaluate bite force. The methods include Digital dynamometer comprising of bite fork and digital body, Electronic strain gauges, Gnathodynamometer, Lever devices, Manometer, Piezo electric force transducer, Pressurized rubber tube connected to a sensor element, Pressure sensitive sheet and an image scanner.

Bite force meter which consists of an electronic strain gauge with a digital indicator is used in this study to evaluate the maximum voluntary bite force in individuals with normal occlusion and in different malocclusions.

Aims & Objectives

AIMS AND OBJECTIVES

The aim of the present study is to investigate the relationship between maximum voluntary bite force and facial morphology.

The study was carried out with the following objectives,

1. To assess the maximum voluntary bite force in children and adults with normal occlusion.
2. To assess the maximum voluntary bite force in adults with Angle's class I malocclusion and skeletal class II malocclusions.
3. To compare the difference in maximum voluntary bite force in adults with normal occlusion and adults with Angle's class I malocclusion and skeletal class II malocclusions.
4. To assess the maximum voluntary bite force in hypodivergent and hyperdivergent facial morphologies in adults
5. To compare the difference in maximum voluntary bite force between adults with normal occlusion and adults with hypodivergent and hyperdivergent facial morphology.

Review of Literature

REVIEW OF LITERATURE

J Wolff (1870)[99] pointed out that the trabecular alignment of the femur head reflects the stress trajectory formed in resistance to manifold functional stresses. The stimulating influence of muscle or extra-functional force seems to produce demonstrable changes in bone. Thus the shape and internal structure of the femur head are related to lower extremity function. This theory is recognized as Wolff's law.

A.H. Howell and R.S. Manly (1948)[22] devised an electronic strain gauge for measuring oral forces which makes use of principle of change in inductance of a coil as a silver plated spring is brought near the coil. The deflection of this spring is proportional to the force applied and the deflection produces a change in inductance on any tooth with a bite opening of 7-10mm.

Harold T Perry Jr (1955)[19] studied the electrical activity of masseter and temporalis muscles using electromyography

Melvin L Moss (1962)[44] suggested that maxillofacial morphology is controlled by development of function including nasal cavity or maxillary sinus and mandible is particularly influenced by masticatory muscle function, with final morphology being dependent upon masticatory muscle activity.

W R Proffit, J W Gamble and R L Christiansen (1968)[59] demonstrated generalized muscular weakening in severe anterior open bite after studying occlusal forces in normal and long faced adults.

Melvin L Moss (1969)[46] applied functional cranial analysis to the mandibular angular cartilage of neonatal mice. Surgical removal of this secondary cartilage resulted in a normal mandible with growth. It was concluded that the angular cartilage plays no role active role in growth of the mandible and form, position and maintenance of angular process is secondary response to the primary morphogenetic demands of its specifically related muscles.

V Sassouni(1969)[70] outlined the concept that the vertical alignment of jaw closing muscles directed skeletal growth towards a shallow mandibular plane angle, an acute gonial angle, and deep bite, whereas obliquely aligned jaw closing muscles with subsequent diminished force permitted a steep mandibular plane angle, an obtuse gonial angle, and openbite.

Margareta Ringqvist (1973)[65] recorded the maximum voluntary isometric bite force at the incisors and at molars in females aged 19-23 years and concluded that bite force was mainly associated with a long mandible and a small gonial angle and 49% of the variation in incisor bite force could be due to variations in the length of the mandible, gonial angle and length of anterior cranial base and 56% of the variation in molar bite force could be due to variations in the length of the mandible, gonial angle and a long maxilla.

B Ingervall (1976)[24] studied the correlation between facial morphology and activity of the temporalis muscle and the musculature of the lips electromyographically during swallowing and chewing. Upper lip activity was low in girls with small face height. Lower lip showed no correlation with facial form. Marked temporal muscle activity was noticed while swallowing in subjects with small face height.

B Ingervall and E Helkimo (1978)[26] studied the relationship between masticatory muscle force and facial morphology in man. The subjects with strong bite force differed from the weak in having an anterior inclination of the mandible with a smaller anterior and a greater posterior face height, a smaller gonial angle, a straighter cranial base and greater depth of the upper face, a tendency towards parallelism between the mandibular occlusal line and the mandibular border as well as a broader maxilla. They concluded that form of the face partly depends on the strength of the muscles.

G.J. prium (1979)[55] evaluated the asymmetries of bilateral static bite forces in difference locations on the human mandible and found that unilateral biting leads to asymmetric loading of the joints and may initiate a complex inhibition of muscle activity, and at low bite forces each subject shows a certain preference for one side and that biting becomes more symmetrical when the bite force is increased.

G.J Prium et al (1980)[56] measured the forces acting on the mandible during bilateral static bite at different bite force levels with a mathematical model, based on an assumed linear relationship between the forces exerted by a muscle and its integrated electromyogram for calculating muscle forces and joint forces and stated that highest bite forces and muscle forces are exerted at the first molar and highest loading of the temporomandibular joints is highest in the first premolar region and joint forces are higher when the bite force is applied more ventrally.

Gaylord S Throckmorton et al (1980)[82] presented a two dimensional model which allows calculation of mechanical advantage of the human temporalis and masseter muscle. The model was manipulated to demonstrate how selected differences in facial morphology affected the mechanical advantage of the muscles and concluded that differences in the mechanical advantage of the muscles. They suggested that the mechanical advantage may, in part, explain observed differences in bite force.

Robert M Beecher and Robert S Corrucini (1981)[67] studied the effects of dietary consistency in the craniofacial and occlusal development in rat. They suggested that the medio-lateral maxillay growth is dependent up on the hard particles in diet.

Floystrand et al (1982)[13] constructed a miniature bite force recorder for studying a large number of subjects. A semiconductor was chosen as the sensory unit. The complete recording system included a power supply, the bite force recorder, a chart recorder and a millivoltmeter. 8 males and 8 females aged 20-25 years old participated in the study showing a bite force ranging from 330 N-680 N and number of bites varied from 5-27. No statistically significant differences were observed between sexes for maximal bite force and number of bites.

W.R.Profit and H.W.fields (1983)[58] found that forces of dental occlusion during swallowing, simulated chewing and hard biting are similar for normal and long faced children and they are similar to forces in long faced adults, and concluded that long faced children do not gain strength in mandibular elevator muscles.

W. R. Proffit, H W Fields and W.L. Nixon (1983)[57] measured bite force during swallowing, simulated chewing and maximum biting effort in 19 long face and 21 normal individuals with quartz and foil based piezo-electric force transducers. Forces were recorded at 2.5mm and 6.0mm molar separation. Long faced individuals had less occlusal force during maximum effort, simulated chewing and swallowing than individuals with normal vertical facial dimensions. No differences in forces were seen between 2.5mm or 6.0mm of jaw separation.

Alan A Lowe and Kenji Takada (1984)[40] studied the association between anterior temporal, masseter, orbicularis oris activity and craniofacial morphology.

H W Fields, W Proffit, J C Case and K W L Vig (1986)[12] studied the variables affecting the measurements of vertical occlusal force during swallowing, simulated chewing and maximum biting in chidren, adolescents and adults. The variables were the extent of vertical opening, contralateral occlusal support and head posture. The results showed that increasing the extent of vertical opening increases the bite force to a maximum at about 20mm followed by a decrease and then a second increase at about 40mm for young adults and no significant differences in vertical force with or without contralateral support or between flexed, normal and extended head postures at either of the small openings were obtained.

Bengt Ingervall et all (1989)[25] studied the correlation between mouth breathing and bite force in children and found that both mouth breathing and bite force were associated with the facial morphology but there was no association between mouth breathing and bite force, and concluded that the long face morphology which is characteristic of mouth breathing children is not due to weak masticatory muscles.

Merete Bakke et al (1990)[3] measured the unilateral bite force in individuals aged 8-68 years and found that bite force was stronger in men than in women and increased till 25 years in both sexes and decreased after 25 years in women and 45 years in men. Body height and occlusal contact was positively correlated with bite force and concluded that normal bite force values provide a reference data for screening of elevator muscle strength.

K.sasaki etal (1989)[69] evaluated the relationship between the size, position and angulation of human jaw muscles and unilateral first molar bite force and found that high correlation was found between sectional size of masseter and medial pterygoid and bite force. No significant correlation was found between muscle or bitepoint level arms and bite force and also concluded that jaw muscle size accounts for most of the variation in bite force.

P.H.van spronsen etal (1989)[85] studied the cross sectional areas of the jaw muscles by MRI and compared those findings with the cross sectional areas of the jaw muscles obtained by computed tomography. CT and MRI cross sectional areas of the masseter and medial pterygoid showed highly positive and significant correlations with maximum voluntary bite force and concluded that MRI has significant advantages over CT for soft tissue imaging.

T.M.G.J.Van Eijden (1990)[92] studied the changes in masseter and temporalis muscles was exerted at different teeth in different directions, and concluded that activities of the right and left side muscles did not differ in a bilateral vertical bite and more muscle activity was required for productions of a constant bite force at the anterior side of the dental arch than at the posterior side. There was a close relationship between the direction of bite force and jaw muscle activity.

Eva Hellsing and Catherine Hagberg (1990)[20] studied the maximum bite force and position of hyoid bone during natural and extended head posture in 15 adults with normal occlusion and full dentitions. The bite force was recorded with a bite force sensor between the first molars in natural and extended head posture and showed that bite force was 321.5N with extended head posture and 271.6N with natural head posture. Change in the position of hyoid bone was associated with change in head posture which might be due to the interplay between the elevator and depressor muscle groups.

Oyen et al (1991)[50] measured the bite force and bone strain in growing African green monkeys to study skull biology and geometry and concluded that force remolding relationship is site specific and tensile stresses are predominant.

Shiau YY, Wang JS (1993)[71] evaluated the effects of dental condition on hand strength and maximum bite force in 2034 children and found that both forces increased relative to the increase of age, weight and height. Boys had stronger bite force and grasp force. Boys became stronger after 13 years and children with decay and missing teeth had weaker bite force and concluded that bite force does not seem parallel hand strength but it is related to dental condition.

J.W. Osborn, J. Mao (1993)[49] devised a thin 2mm thick bite force transducer, capable of measuring the magnitude and direction of bite force in three dimensions and found that initial bite force was directed about 10-15° forward of the vertical and magnitude of bite force was constant and found that it is a useful tool for studying human jaw biomechanics.

Kiliaridis et al (1995)[32] evaluated the effects of chewing training on the strength and resistance to fatigue of the masticatory muscles and concluded that 4 week training in adults with a hard chewing gum influences the functional capacity of the masticatory muscles and increase their strength but there was no change in fatigue resistance.

Kiliaridis et al (1995)[29] studied the relationship between craniofacial morphology, occlusal traits and bite force in individuals with advanced occlusal tooth wear and concluded that individuals with increased tooth wear had higher bite force and increased activity of masticatory muscles, which may be due to para function or the effect of a higher tolerance level in the mechanism controlling masticatory muscle contraction and reduced mandibular-palatal plane angle and small gonial angle were significantly correlated to high occlusal tooth wear.

G. P. Thomas et al(1995)[81] evaluated the changes in mandibular motion and maximum bite force that occur between the initiation of pre surgical orthodontics and its completion before surgery and concluded that significant reductions in bite force was noted which may be due to pain and discomfort of the orthodontic appliances and the induced malocclusion.

Stanley Braun et al (1996)[77] measured the mean maximum bite force in males and females from 6 years through 20 years in the deciduous first molar or permanent first premolar region. The measurements ranged from 78 Newtons at 6-8 years to 176 Newtons at 18-20 years. It was concluded that maximum bite force increases during growth and development without grade specificity and it increases at a greater rate in males than females in post pubertal period.

Bengt Ingervall etal (1997)[27] studied the correlation between maximum site force and facial morphology in 54 boys aged 8-16 years and 66 girls aged 17 years old, bite force was measured at the first molar with a miniature bite force recorder and facial morphology was evaluated on profile cephalograms and number of teeth is contact is the intercuspal position was recorded with occulusal foils. In the girls, maximum bite force was calculated with the inclination of the mandible, size of the gonial angle and ratio between posterior and anterior face heights. Bite force was negatively correlated to mandibular inclination and gonial angle and positively correlated with ratio of posterior facial height to anterior facial height. These calculations were nonexistent or weaker in boys. In both sexes, bite force was positively correlated with number of occulusal contacts.

T. Nagashima et al (1997)[48] studied the magnitude of the impact velocity after a sudden unloading at various initial bite forces, degrees of mouth opening and distance of travel and found that the rapid decline in bite force coupled with a limitation of impact velocity is due to the force- velocity properties of the active jaw muscles and is not caused by neural control.

M.Kikuchi et al (1997)[28] studied the association among occlusal contacts, clenching effort and bite force distribution in adults and concluded that the jaw muscle size and direction of muscle action lines and skeletal relationships such as zygomatic arch width, ramus height and gonial angle determines the mechanical performance of the masticatory apparatus and the bite force gradient.

G.E Slager et al (1998)[74] studied whether the magnitude of the low residual bite force is dependent on the initial bite force, initial degree of mouth opening and the distance of jaw travel and found that the residual forces are largely dependent on the distance of jaw travel and insensitive to variations in mouth opening , and magnitude of bite force and low residual forces are 25% of initial bite and brought force about by non uniform sarcomere behaviour of the jaw closing muscles during contraction or a long lasting change in the myofilament systems of the closing muscles induced by the sudden shortening of muscle fibers.

M.C. Raadsheer et al (1999)[61] assessed the relative contributions of jaw muscle size and facial morphology to the maximum voluntary bite force magnitude by measuring bite force, jaw muscle size and morphology of the face. Magnitude and direction of bite force was measured with a bite force transducer and facial morphology with anthropometry and cephalometry and jaw muscle thickness with ultrasonography. Thickness of the masseter muscle, vertical and transverse facial dimensions, inclination of the midface correlated positively and mandibular inclination and occlusal plane inclination correlated negatively with bite force magnitude.

Granger et al (1999)[17] evaluated the masticatory muscle function in patients with spinal muscular atrophy and found that maximum bite forces were decreased to half of the normal values, maximum opening and protrusion were reduced by half but EMG activity was not significantly different and concluded that masticatory muscles are weakened and they are less efficient and fatigue occurs quickly and mandibular movements take place over a limited range of motion, in individuals with spinal muscular atrophy.

O. Hidaka et al (1999)[21] evaluated the influence of clenching intensity on bite force balance, occlusal contact area and average bite pressure and found that bite force and occlusal contact area increased with clenching intensity, and average bite pressure was unchanged and concluded that as the clenching intensity increases in the intercuspal position, bite force adjusts to a well balanced position which prevents damage and overload to the teeth and temporomandibular joints.

C.K. Yeh et al (2000)[101] studied the relationship between salivary flow rates and maximum bite force in adults and found that bite force and salivary gland function have a direct correlation that is independent of age and gender.

Lioselotte Sonnesen, Merete Bakke, Beni Solow (2001)[39] examined the associations between craniofacial dimensions, head posture, bite force and symptoms and signs of temporomandibular disorders and concluded that TMJ dysfunction was seen in connection with forward inclination of cervical spine and an increased craniocervical angulation. Muscle tenderness and lower bite force was evident in individuals with long face type.

Lisolotte Sonnesen et al (2001)[38] measured the bite force in children with unilateral posterior crossbite with a pressure transducer and found that maximum bite force increased with age, increasing stages of dental eruption and bite force was smaller in crossbite group and early treatment of unilateral posterior crossbite is advisable to optimize function.

A.M Rentes et al (2002)[63] determined the bite force in children with normal occlusion, cross bite, openbite in primary dentition with a pressurized transmitter tube and concluded that the type of occlusion did not affect the maximum values of the bite force and body variables such as height and weight had a small influence in the magnitude of bite force.

Morales, Buschang et al (2003)[47] correlated maximum bite force and masticatory muscle electromyographic activity with craniofacial morpphology and mechanical advantage of children with vertical growth patterns and concluded that children with large faces have larger moment arms and require less muscle activity to attain any given force and greater hyperdivergence is related to poor mechanical advantage and lower maximum bite force similar to those reported in adults.

M.C. Raadsheer et al (2004)[62] investigated the influence of general factors like genotype, hormones and factors at the craniofacial level like craniofacial size, jaw muscle architecture on the size and strength of jaw muscles and found that the size of the jaw muscles correlated with size of the limb muscles but bite force moments were not related to the moments of the arm flexion and leg extension forces suggesting that bite force values are influenced by general factors and craniofacial morphology.

Lioselotte Sonnesen, Merete Bakke(2005)[36] examined the bite force in relation to occlusion, craniofacial dimensions and head posture in 88 children aged 7-13 years and bite force was measured with a pressure transducer. They concluded that bite force does not vary significantly between the Angle malocclusion types and bite force increased with age in girls, with teeth in occlusal contact in boys and with increasing number of teeth in both genders. No correlation was found between bite force and head posture. Vertical jaw relationship the number of teeth present were the most significant factors for the magnitude of bite force in boys and girls.

Tetsuya Kamegai et al (2005)[79] measured the bite force of 2594 school children (1248 males and 1346 females) with an occusal force gauge which consisted of a hydraulic pressure gauge, with a bite element encased in a plastic tube. The subjects comprised of 73 nursery (3-5 years old), 1019 primary 6-11 years old, 902 junior high (12-14 years old) and 600 high (15-17 years) school children. Bite force was measured at the first molar in the permanent dentition and in second primary molar in primary dentition. Bite force was 186.2N in males and 203.4 N in females of necessary school children. 374.4 N in females of primary 545.3 N in males and 395.2 N in females of high school children and concluded that bite force increases with age from 3-14 years in both males and females and presence of certain malocclusions adversely affects the bite force.

Andrew Pepicelli et al (2005)[52] presented a review article on the mandidibular muscles and vertical facial pattern. The muscles of the maxilla and mandible seem to play an important role in the etiology and active treatment of malocclusions and jaw deformities and also for the stability of such treatment. In dolichofacial subjects, smalle4r bite forces have been found than in mesofacial and brachyfacial subjects. Facial morphology has been correlated with bite force and cross sectional area of the mandibular muscles.

Lemos. A. D. et al (2006)[34] correlated the chewing performance and maximum bite force in children, and found that high bite forces implicated in better chewing performance and was weakly correlated with BMI and children with different molar and canine relationships did not show differences among variables and concluded that chewing performance depends on maximum bite force, number and area of occlusal contacts and amount of lateral excursion during mastication.

Merete Bakke (2006)[2] explained that maximum bite force is a useful indicator of the functional state of the masticatory system and the loading of the teeth. Maximum bite force averages 300-600 N and is the anterior region it is about 40% and is the premolar region it is about 70% of the maximum bite force does not vary between angle malocclusion types.

Calderon P.D.S et al (2006)[7] evaluated the influence of gender and bruxism on the maximum bite force. Bite force was measured with a gnathodynamometer and found that bite force was higher for males compared to females and pressure of bruxism did not influence the bite force.

Ephraim Winocur et al (2007)[98] evaluated the postorthodontic change of the masticatory muscles using three parameters – maximum voluntary muscle bite force, centric slide and muscle sensitivity to palpation. Bite force was measured with a custom made rubber tube bite force device, centric slide with a digital caliper and sensitivity to muscle palpation by applying a standard digital force and concluded that neuromuscular adaptability begins within several minutes after bracket removal and second stage of muscular adaptation occurs with in 3 months of retention suggesting that muscular adjustment occurs within a short period after orthodontic treatment.

Lisolotte Sonnesen and Merete Bakke (2007)[37] measured bite force in children with unilateral posterior cross bite before, immediately after treatment and after retention and found that bite force level was reduced immediately after treatment, but increased again after retention and approached the bite force level in children with neutral occlusion . The fluctuation in bite force level during treatment may be due to transient changes in occlusal support, periodontal mechanoreceptors and jaw elevator muscle reflexes.

Gaviao etal (2007)[53] evaluated the ultrasonographic thickness of the masseter and anterior temporalis, maximum bite force and number of occlusal contacts in children with normal occlusion and unilateral crossbite and found that thickness of masseter positively correlated with bite force and anterior temporalis thickness at rest was thicker for cross bite side and concluded that functional and anatomical variables differ in presence of malcocclusion and early diagnosis and treatment planning.

Rosemary S. Shinhai et al (2007)[73] evaluated whether the variation in vertical facial pattern is related to variation in maximum occlusal force in adults and found no significant difference among dolicofacial, mesofacial or brachyfacial individuals and concluded that maximum occlusal force and median mandibular flexure do not correlate with vertical facial pattern.

Gaviao.M.B.D et al (2007)[15] evaluated the masticatory performance and bite force in children with primary dentition and concluded that masticatory performance was independent of muscular force and body variables had no influence upon masticatory muscles could be considered.

Pereira etal (2007)[53] evaluated the signs and symptoms of TMD, masseter and anterior temporalis thickness, facial dimensions and bite force in adolescents and found that muscle thickness influences facial dimensions and biteforce.

Materials & Methods

MATERIALS AND METHODS

Subjects

This study was conducted on 140 subjects in Tamilnadu government dental college and hospital. 30 children in the age group of 7-11 years and 110 adults in the age group of 17-25 years were selected. Specific inclusion criterion for children was complete eruption of permanent first molars, no gross decay of permanent first molars and class I normal occlusion. Specific inclusion criterion for adults was class I normal occlusion, full complement of permanent dentition, no gross decay of permanent first molars and first premolars. Subjects with previous history of orthodontic treatment, TMJ dysfunction, and signs of neurologic disease, chronic illness, gross decay, extensive restoration and missing permanent first molars were excluded from the study. The status of third molars was not considered in this study.

Based on selected lateral cephalometric measurements and clinical findings, hundred and forty subjects were divided in to various groups. 30 children (15 males, 15 females) aged between 7-11 years with class I normal occlusion belong to **GROUP A**, 30 adults (15 males, 15 females) aged 17-25 years with class I normal occlusion belong to **GROUP B**. Subjects in Group A and Group B were considered as control group. Based on sagittal skeletal relationships, twenty adult with Angle's class I malocclusion belong to **GROUP C** and twenty adult subjects with skeletal class II malocclusion belong to **GROUP D**.

The criteria used for classifying class I and skeletal class II malocclusions are given in Table 1.

Table1: Measurement criteria for Classifying Sagittal Jaw Relationships

MEASUREMENT	SKELETAL CLASS I	SKELETAL CLASS II
ANB	2^o-4^o	$>4^o$
BETA ANGLE	27^o-35^o	$<27^o$
AO-BO	0-1mm	>1mm

Based on vertical skeletal relationships, twenty subjects with hypo divergent facial morphology belong to **GROUP E** and twenty subjects with hyper divergent facial morphology belong to **GROUP F**. The criteria used for classifying hypo divergent and hyper divergent facial morphology are given in Table 2.

Table 2: Measurement criteria for Classifying Vertical Jaw Relationships

MEASUREMENT	NORMODIVERGENT	HYPODIVERGENT	HYPERDIVERGENT
FMA	20^o -30^o	$<20^o$	$>30^o$
Basal plane angle	27^o -34^o	$<27^o$	$>34^o$
Gonial angle	120^o -128^o	$<120^o$	$>128^o$
Jarabak's ratio	59-62%	>62%	<59%

PROTOCOL METHOD:

The subjects were explained about the purpose of the study and an informed consent was obtained from them. Clinical examination was done and the following details were recorded and included in the specially designed proforma.

(Annexure-1)

- Name:
- Age:
- Sex:
- Father's name:
- Occupation:
- Address:
- Medical history:
- Extaroral examination

    Body type:

    Facial type:

    Profile:

    Clinical FMA

- Intraoral examination

    No. of teeth present

    Molar relation

    Canine relation

    Over jet

    Over bite

    Transverse relation

ARMAMENTARIUM

The armamentarium for this study included

A. For clinical examination (photoplate-1)

1. Mouth mirror
2. Explorer
3. Sterile disposable latex gloves.

B. For lateral cephalometric radiographs (photo plate -6, 7, 8, 9)

1. Blue base Kodak T mat X-ray film of 8 X 10 inches size
2. PM 2002 CC PROLINE X-ray machine manufactured by Planmeca OY, Finland
3. X-ray Illumination box
4. 4H pencil
5. Tracing sheet

C. For measuring bite force (photo plate 3, 4, 5)

1. Strain gauge mounted probe (Veltronix Industries)
2. Digital bite force display
3. Putty silicone (GAC International)

LATERAL CEPHALOGRAMS:

Lateral cephalometric radiographs was taken for all the subjects in the same cephlostat by a single operator in the natural head position with Frankfort horizontal plane parallel to the floor and teeth in centric occlusion. Blue base Kodak T mat X-ray films of 8 X 10 inches size exposed at 70Kvp, 30 mA for 1.8 seconds from a fixed distance of 60 inches was used. All the cephlograms were taken in PM 2002 CC PROLINE machine manufactured by Planmeca OY, Finland in the department of Oral Medicine and Radiology, Tamilnadu Government Dental College and Hospital and were hand traced by a single individual to avoid inter individual variability.

The following cephalometric landmarks were used in the study: (figure 2)

1. **ANS (Anterior nasal spine):** The anterior tip of the sharp bony process of maxilla at the lower margin of anterior nasal opening**.**
2. **Cd (Condylion):** Most superior point on head of condyle.
3. **Go (Gonion):** A point on the curvature of angle of the mandible located by bisecting the angle formed by lines tangent to posterior ramus and inferior border of the mandible.
4. **Me (Menton):** Lowest point on the symphyseal shadow of the mandible seen on the lateral cephalograms.
5. **N (Nasion):** Most anterior point on the fronto-nasal suture in the mid-sagittal plane.

6. **PNS (Posterior nasal spine):** Posterior spine of the palatine bone constituting the hard palate.
7. **Point A (Subspinale):** The deepest midline point in the concavity between anterior nasal spine and the most inferior point on the alveolar bone overlying the maxillary incisors.
8. **Point B (Supramentale):** The deepest midline point in the concavity of the mandible between the most superior point in the alveolar bone overlying lower incisors and most anterior point of chin.
9. **S (Sella):** The midpoint of hypophyseal fossa.

Linear measurements from lateral cephalogram:

1. S (Sella)-N (Nasion) – Anterior cranial Base Length
2. LAFH -- Lower anterior facial height
3. LPFH -- Lower posterior facial height
4. TAFH -- Total anterior facial height
5. TPFH -- Total posterior facial height
6. AO-BO- Wits appraisal

ANGULAR MEASUREMENTS FROM LATERAL CEPHALOGRAM:

1. SNA
2. SNB
3. ANB
4. Beta angle
5. Gonial angle (CdGo to GoMe)
6. Mandibular plane angle (FH to GoMe)
7. Basal plane angle (ANS-PNS to GoMe)

Proportional measurements:

1. LAFH (Lower anterior facial height)/TAFH (Total anterior facial height)

2. LPFH (Lower posterior facial height)/TPFH (Total posterior facial height)

STRAIN GAUGE MOUNTED PROBE

A **strain gauge** is a device used to measure deformation (strain) of an object. Invented by Edward E. Simmons and Arthur C. Ruge in 1938, the most common type of strain gauge consists of an insulating flexible backing which supports a metallic foil pattern. The gauge is attached to the object by a suitable adhesive, such as cyanoacrylate. As the object is deformed, the foil is deformed, causing its electrical resistance to change. This resistance change, usually measured using a Wheatstone bridge, is related to the strain by the quantity known as the *gauge factor*. The gauge factor *GF* is defined as where R_G is the resistance of the undeformed gauge, ΔR is the change in resistance caused by strain, and ε is strain. For metallic foil gauges, the gauge factor is usually a little over 2. For a single active gauge and three dummy resistors, the output *v* from the bridge is where *BV* is the bridge excitation voltage.

Table 3

General Properties of Strain Gauge

Measurable strain	2 to 4% max
Thermal output 20° c to 160° c 160◦c to 180◦ c	 12 micro strain/◦c 15 micro strain per ◦c
Gauge factor change With temperature	 10.015%/c max
Gauge resistance	120 ohms
Gauge resistance tolerance	10.5%
Fatigue life	>100000 reversals @100 microstrain (1 microstrain = 0.0001% extension)
Foil material	copper nickel alloy

Table 4
Specification of a strain gauge

Temperature change	-30◦c to +80◦c
Gauge length	5mm
Gauge width	2mm
Gauge factor	2.1
Base length (single types)	13.0mm
Base width (single types)	4.0mm

Construction and Principle of Operation of Strain Gauge: (figure 1)

The strain gauge measuring grid is manufactured from a copper nickel alloy, which has a low and controllable temperature coefficient. The actual form of the grid is accurately produced by photo etching techniques.

Thermoplastic film is used to encapsulate the grid, which helps to protect the gauge from mechanical and environmental damage and also acts as a medium to transmit the strain from the test object to the gauge material.

The principle of operation of the device is based on the fact that the resistance of an electrical conductor changes with a ratio of FR/R. When a stress is applied such that its length changes by a factor FL/L, where FR is a change in resistance from unstressed value, and FL is change in length from original unstressed length. The change in resistance is brought about mainly by the physical size of the conductor changing and an alteration of the conductivity of the material, due to changes is the materials structure.

Copper nickel alloy is commonly used in strain gauge construction because the resistance change of the foil is virtually proportional to the applied strain

i.e., FR/R=K.E

Where K is a constant known as a gauge factor,

FL/L=FR/R

And E=Strain =FL/L/K=FR/RE

The change in resistance of the strain gauge can therefore be utilized to measure strain accurately when connected to an appropriate measuring and indicating circuit.

Probe:

The probe consists of a tuning fork shaped hardened steel fork on the inner side of one of the fork arm, the strain gauge is fixed. The probe is hardened so that it is not deformed on application of excessive pressure but still retains its original shape.

Digital display circuit:

The electronic circuit consists of 3 stages.

The **first stage** consists of the strain gauge and its peripheral circuitry. On application of strain on the strain gauge, the electrical properties of the gauge changes resulting in the change of the output voltage which is of very low magnitude.

This output voltage is fed to the input of the second stage.

The **second stage** consists of a differential amplifier and a signal amplifier. The output voltage from the first stage is fed to the differential amplifier and the output of the differential amplifier is fed to a signal amplifier. The signal amplifier increases the magnitude of the signal to acceptable levels and also reduces the DC noise. The output is an analog signal.

The output of II stage is fed to the input of the third stage.

The **third stage** consists of an analog to digital converter circuit which converts the analog signals from the second stage in to digital data which is displayed on the digital display. The analog to digital converter also consists of a calibration circuit which is used to calibrate the output display value.

BITE FORCE MEASUREMENTS

All the subjects were comfortably seated with natural unsupported posture looking straight and procedure was explained to them. The maximum voluntary bite force was measured with a bite force meter (Veltronix Industries) which consists of a strain gauge mounted probe and digital display indicator. The bite force probe tip was covered with putty silicone to prevent damage to the teeth and mouth opening was adjusted to 15mm. To prevent contamination between patients this material was changed after each use. Bite force measurements were taken between the occluding surface of maxillary and mandibular teeth. Measurements were taken at the right and left first molars, right and left first premolars. For children the bite force was recorded only in the right and left permanent first molars. The measurements were taken with the probe tip placed against the occlusal surface of the lower teeth and patient being asked to close on to the gauge in a natural closing arc. The subjects were asked to bite on to the gauge as hard as possible and the value is recorded as the maximum voluntary bite force of that tooth. The opposite side bite forces were recorded in the same way. The values were recorded and statistically analyzed.

STATISTICAL ANALYSES

Student t test was done to compare the difference in bite force between two groups and to assess the gender difference. ANOVA was done for multiple comparisons.

The t-test assesses whether the means of two groups are statistically different from each other. This analysis is appropriate whenever you want to compare the means of two groups.

$$T = \frac{\overline{X} - \overline{Y}}{\sqrt{\frac{S_X^2}{n_1} + \frac{S_Y^2}{n_2}}}$$

In statistics One-Way Analysis of Variance (abbreviated One-Way ANOVA) is a technique used to compare means of three or more populations at the same time. It is important that this technique can be used only for numerical data. One-Way ANOVA is using F distribution with F = t squared

$$\text{SS total} = \left(\sum x_1^2 + \sum x_2^2 + \sum x_3^2\right) - \frac{\left(\sum x_1 + \sum x_2 + \sum x_3\right)}{N}$$

$$\text{SS total} = \left(\frac{\left(\sum x_1\right)^2}{n_1} + \frac{\left(\sum x_2\right)^2}{n_1} + \frac{\left(\sum x_3\right)^2}{n_1}\right) - \frac{\left(\sum x_1 + \sum x_2 + \sum x_3\right)}{N}$$

SS within = SS total - SS among

df among = r -1 df within = N –r

$$MS_{among} = \frac{SS_{among}}{df_{among}}$$

$$MS_{within} = \frac{SS_{within}}{df_{within}}$$

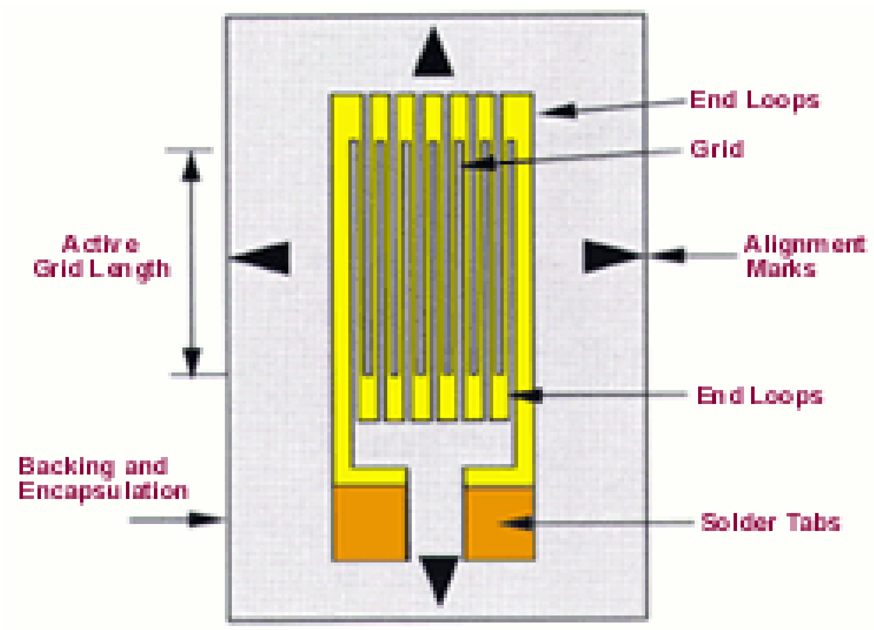
$$F = \frac{MS_{among}}{df_{within}}$$

X = individual observation
r = number of groups
N = total number of observation (all groups)
n= number of observation in group

ANOVA was used to compare the mean bite force value of various groups. The observed p value is significant at 1% level.

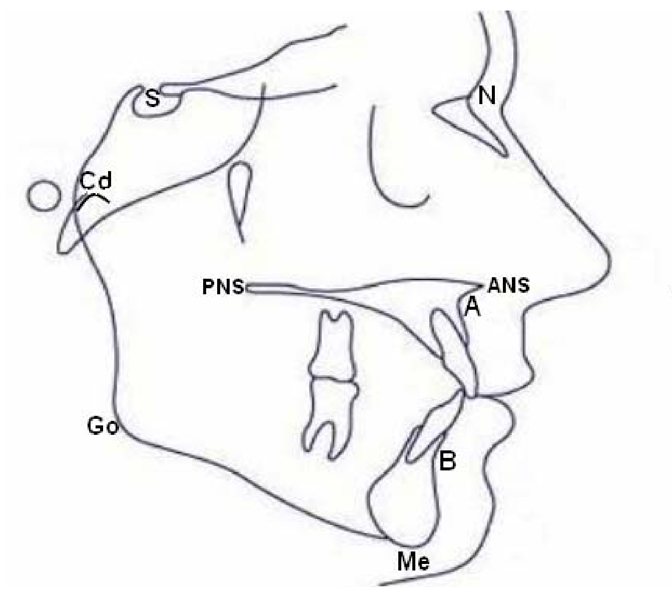
<u>Figure 1</u>

Parts of a strain gauge



<u>Figure-2</u>

Lateral Cephalometric landmarks



PHOTOPLATES

Photoplate-1

Armamentarium for Clinical Examination

Photoplate-2

Strain Gauge

Photoplate-3

Bite Force Meter- Electronic Strain Gauge and Digital Display Indicator

Photoplate- 4

Armamentarium for Measuring Bite Force

Photoplate-5

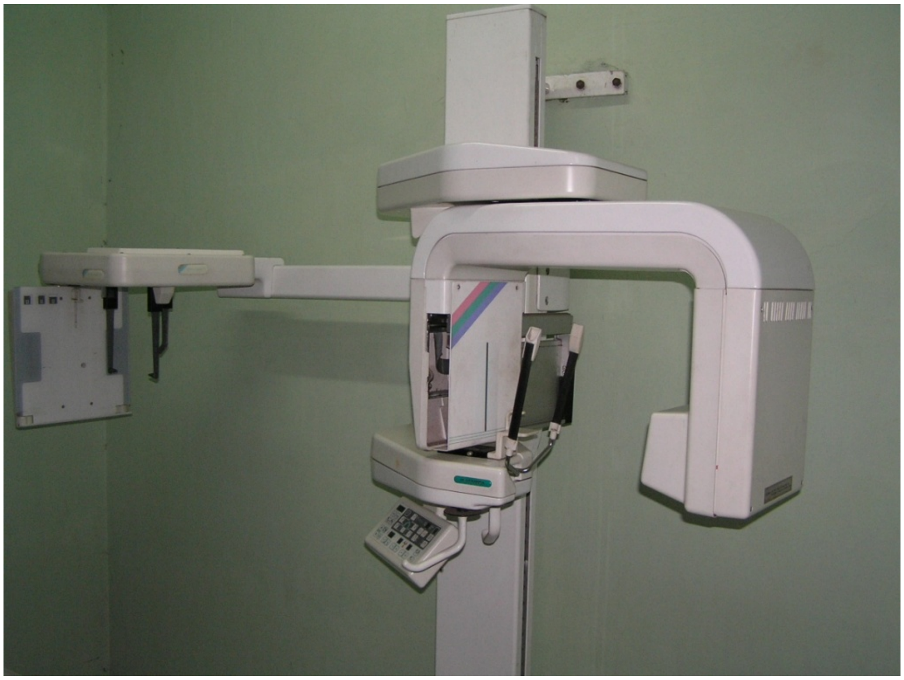
Bite Force Measurement

Photoplate-6

Extra Oral 8× 10” X Ray Film

Photoplate-7

Cephlostat



Photoplate-8

Positioning For Lateral Cephalogram

Photoplate-9

Lateral Cephalogram

Lateral Cephalogram with Tracing

Results

RESULTS

The study sample consists of 140 subjects. 30 Children with normal occlusion were selected and bite force was measured in permanent first molar. 110 adults were evaluated for bite force in first molar and first premolar region. Lateral cephalograms were taken for all the subjects. Based on certain cephalometric measurements, the subjects were divided in various groups. 30 children belong to **Group A**.30 adults with normal occlusion served as the control group and belong to **Group B**. Based on sagittal relationships, Adults with Angle's class I malocclusion belong to **Group C** and adults with skeletal class II malocclusion belong to **Group D**. Based on vertical skeletal relationships, adults with hypo divergent facial morphology belong to **Group E** and adults with hyper divergent facial morphology belong to **Group F**. Groups C, D, E, F consists of 20 subjects. Bite force was assessed with a bite force meter which consists of an electronic strain gauge and a digital display indictor.

The data thus obtained was analyzed statistically using Statistical Package for Social Sciences. Student paired't' test was used to analyse the difference in molar and premolar bite force value between groups B,C,D,E,F and also to analyse the gender difference in groups A,B. Results were considered as significant at a p value < 0.05.

ANOVA was used to analyze the difference in bite force value among groups B, C, D, E, and F. In ANOVA, the observed p value is significant at 1% level.

Interpretation of results

The results showed that the mean bite force value in each of the group was found to be 191.17N (**Group A**), 601.83N (**Group B**), 592.60 N (**Group C**), 586.60N (**Group D**), 771.50N (**Group E**), 283.85N (**Group F**). The standard deviation for each of the groups was 11.47, 60.80, 37.66, 49.26, 27.24, and 26.41. (Tables 8, 9, graph 3-7)

The results obtained from student‘t’ test shows highly significant difference in bite force value between group A and B with a p value <.001 (Table 7, graph 1) suggesting that bite force varies significantly. From the results, a high significant difference in bite force value is found between group B and E and group B and F with a p value of <**0.0001**. (Tables 9C, D, graph 6, 7) No significant difference was observed between group B and group C (p 0.5481and 0.1148) (graph 4) and group D (p 0.3551 and 0.0949). (Tables 9A, B, graph 5)Significant gender difference between the means of bite force values was found in adults with a p value of **0.0418**(Table 8, graph 3) but gender difference in children was not statistically significant with a P value of 0.1697. (Table 6)

The result obtained from ANOVA (Table 10) shows that there was a highly significant difference between the means of bite force values among groups B, E and F. No significant difference between the means of bite force values among groups B, C and D. A column chart was used to represent the gender difference in children and adults and mean bite force value between various groups.

TABLES

Table- 5

Bite Force Data (Newtons)

S. no	GROUP A	GROUP B	
	Molar	Molar	Premolar
1	201	522	340
2	185	576	374
3	170	621	404
4	179	501	326
5	198	548	356
6	186	539	350
7	192	567	368
8	178	583	378
9	205	641	416
10	187	532	346
11	190	633	412
12	211	688	448
13	186	657	426
14	209	628	408
15	179	697	452
16	188	642	418
17	215	598	388
18	197	574	372
19	184	532	346
20	175	624	406
21	198	639	404
22	194	680	400
23	173	526	398
24	196	587	392
25	179	519	410
26	204	527	412
27	189	687	424
28	192	683	416
29	195	675	388
30	200	629	384

Bite Force Data (Newtons)

S no	GROUP C		GROUP D		GROUP E		GROUP F	
	MOLAR	PREMOLAR	MOLAR	PREMOLAR	MOLAR	PREMOLAR	MOLAR	PREMOLAR
1	602	350	540	348	818	532	330	214
2	540	366	560	408	769	500	319	208
3	628	386	618	298	775	504	253	164
4	606	378	500	320	802	522	275	178
5	624	358	528	356	813	528	279	182
6	638	362	520	344	746	484	253	164
7	628	380	560	360	750	488	248	162
8	616	372	572	358	813	528	308	200
9	586	404	620	406	742	482	298	194
10	590	386	512	338	772	502	265	172
11	548	346	620	400	769	500	259	168
12	618	384	592	430	723	470	321	208
13	614	412	640	412	741	482	325	212
14	620	400	620	396	758	492	254	166
15	530	380	684	382	741	482	268	174
16	568	442	632	402	792	514	293	190
17	524	360	586	368	775	504	275	180
18	536	356	578	352	761	494	301	196
19	628	374	668	376	745	484	282	184
20	608	382	536	386	800	520	271	176

TABLE 6

Comparison of molar bite force in children with class I normal occlusion among males and females (Student paired 't' test)

GROUP A	Mean ± Std.Deviation	T	P value
MALES	199.27000 ± 33.92733	1.4095	0.1697
FEMALES	183.07000 ± 28.81500		

P value and statistical significance:

The two-tailed P value equals 0.0332

By conventional criteria, this difference is considered to be statistically significant.

TABLE 7

Comparison of bite force in children and adults with class I normal occlusion (Student paired 't' test)

GROUP	Mean ± Std.Deviation	T	P value
GROUP A	191.17 ± 11.47	36.353	**<0.001**
GROUP B	601.83 ± 60.80		

P value and statistical significance:

The two-tailed P value < 0.001 By conventional criteria, this difference is considered to be statistically highly significant.

TABLE 8

Comparison of Molar and premolar bite force in adult males and females with class I normal occlusion (Student paired 't' test)

GROUP	SEX	MOLAR			PREMOLAR		
		MEAN ± SD	**t**	**P value**	**MEAN ± SD**	**T**	**P value**
GROUP B	MALE	650.67 ± 34.18	2.133 2	**0.0418**	422.933 ± 22.214	2.2398	**0.0332**
	FEMALE	543.00 ± 37.14			349.450 ± 24.144		

P value and statistical significance:

The two-tailed P value is < 0.05, this difference is considered to be statistically significant.

TABLE 9

9A. Comparison of bite force among Adults with class I normal occlusion and Angle's class I malocclusion (Student paired 't' test)

	MOLAR			PREMOLAR		
GROUP	**MEAN± SD**	**T**	**P value**	**MEAN ± SD**	**T**	**P value**
GROUP B	601.83 ± 60.80	0.6048	0.5481	392.07 ± 31.43	1.6062	0.1148
GROUP C	592.60 ± 37.66			378.90 ± 23.00		

P value and statistical significance:

The two-tailed P value is > 0.05, this difference is considered to be statistically not significant

9 B. Comparison of bite force among Adults with class I normal occlusion and skeletal class II malocclusion (Student paired 't' test)

	MOLAR			PREMOLAR		
GROUP	**MEAN± SD**	**T**	**P value**	**MEAN± SD**	**t**	**P value**
GROUP B	601.83 ± 60.80	0.9337	0.3551	392.07 ± 31.43	1.7037	0.0949
GROUP D	586.60 ± 49.26			377.00 ± 29.38		

P value and statistical significance:

The two tailed p value is > 0.05, this difference is considered to be statistically not significant.

9 C. Comparison of bite force among Adults with class I normal occlusion and Hypo divergent facial morphology (Student paired 't' test)

	MOLAR			PREMOLAR		
GROUP	**MEAN ± SD**	**T**	**P value**	**MEAN ± SD**	**t**	**P value**
GROUP B	601.83 ± 60.80	11.69 14	**0.0001**	392.07 ± 31.43	13.9271	**0.0001**
GROUP E	771.50 ± 27.24			500.60 ± 18.25		

P value and statistical significance:

The two tailed p value is < 0.0005, this difference is considered to be statistically highly significant

9 D. Comparison of bite force among Adults with class I normal occlusion and Hyper divergent facial morphology (Student paired 't' test)

	MOLAR			PREMOLAR		
GROUP	**MEAN ± SD**	**T**	**P value**	**MEAN ± SD**	**t**	**P value**
GROUP B	601.83 ± 60.80	21.9884	**0.0001**	392.07 ± 31.43	26.9069	**0.0001**
GROUP F	283.85 ± 26.41			184.60 ± 17.16		

P value and statistical significance:

The two tailed p value is < 0.0005, this difference is considered to be statistically highly Significant.

9 E. Comparison of bite force among Adults with Angle's class I malocclusion and Skeletal class II malocclusion (Student paired 't' test)

	MOLAR			PREMOLAR		
GROUP	**MEAN± SD**	**t**	**P value**	**MEAN± SD**	**t**	**P value**
GROUP C	592.60 ± 37.66	0.4329	0.6675	378.90 ± 22.9868	0.2278	0.8210
GROUP D	586.60 ± 49.26			377.0 ± 29.3819		

P value and statistical significance:

The two tailed p value is > 0.5, this difference is considered to be statistically not significant

9 F. Comparison of bite force among Adults with Hypo divergent and Hyper divergent facial morphology (Student paired ‘t’ test)

	MOLAR			PREMOLAR		
GROUP	**MEAN+ SD**	**T**	**P value**	**MEAN+ SD**	**t**	**P value**
GROUP E	771.50 ± 27.24	57.4636	**0.0001**	500.60 ±18.25	56.3998	**0.0001**
GROUP F	283.85 ± 26.41			184.60 ± 17.16		

P value and statistical significance:

The two tailed p value is < 0.0005, this difference is considered to be statistically highly significant

TABLE 10

10 A. ANOVA for comparison of molar bite force between the groups in adults

Source	DF	Sum of Squares	Mean Square F	F Value	P
Between groups	4	2484337.852	621084.463	303.28	<.0001
Within groups	105	215029.467	2047.900		
Total	109	2699367.318			

10 B. ANOVA for comparison of premolar bite force between the groups in adults

Source	DF	Sum of Squares	Mean Square	F Value	P
Between groups	4	1045640.406	261410.102	409.54	<.0001
Within groups	105	67021.267	638.298		
Total	109	1112661.673			

Significant at 1% interval

10 C. Multiple Comparison of molar bite force in adults with ANOVA

Tukey HSD

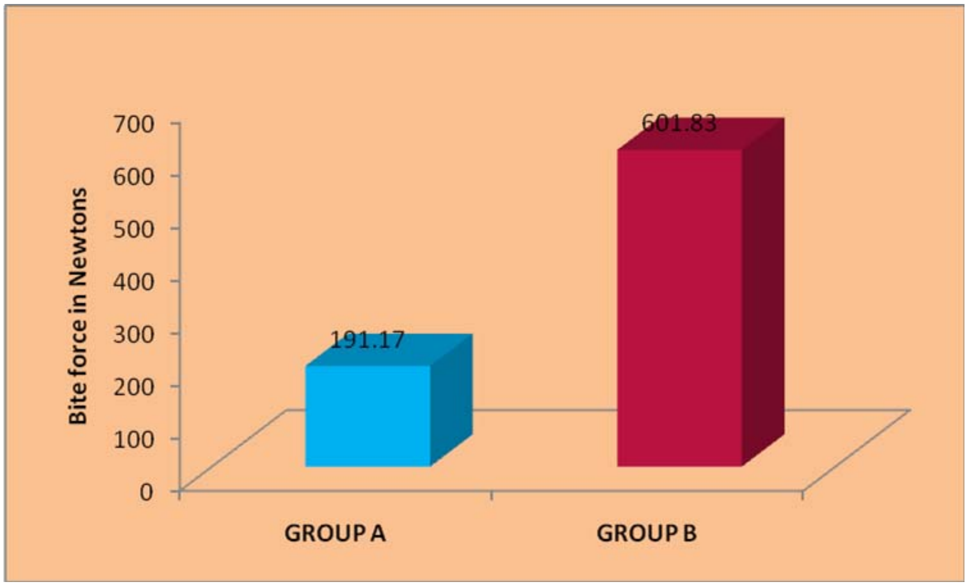
Group comparison	Difference between means	95% Confidence limits		Significance
		Lower Bound	upper bound	
E-B	168.42	132.16	204.68	***
E-C	177.65	137.93	217.37	***
E-D	185.95	146.23	225.67	***
E-F	486.40	446.68	526.12	***
B-E	-168.42	-204.68	-132.16	***
B-C	9.23	-27.03	45.49	
B-D	17.53	-18.73	53.79	
B-F	317.98	281.72	354.24	***
C-E	-177.65	-217.37	-137.93	***
C-B	-9.23	-45.49	27.03	
C-D	8.30	-31.42	48.02	
C-F	308.75	269.03	348.47	***
D-E	-185.95	225.67	-146.23	***
D-B	-17.53	-53.79	18.73	
D-C	-8.30	-48.02	31.42	
D-F	300.45	260.73	340.17	***
F-E	-486.40	-526.12	-446.68	***
F-B	-317.98	-354.24	-281.72	***
F-C	-308.75	-348.47	-269.03	***
F-D	-308.45	-340.17	-260.73	***

10 D. Multiple Comparison of premolar bite force in adults with ANOVA Tukey HSD

Group comparison	Difference between means	Confidence limits		Significance
		Lower bound	Upper bound	
E-B	108.533	88.289	128.778	***
E-C	121.700	99.524	143.876	***
E-D	123.600	101.424	145.776	***
E-F	316.000	293.824	338.176	***
B-E	-108.533	-128.778	-88.289	***
B-C	13.167	-7.078	33.411	
B-D	15.067	-5.178	35.311	
B-F	207.467	187.222	227.711	***
C-E	-121.700	-143.876	-99.524	***
C-B	-13.167	-33.411	7.078	
C-D	1.900	-20.276	24.076	
C-F	194.300	172.124	216.476	***
D-E	-123.600	-145.776	-101.424	***
D-B	-15.067	-35.311	5.178	
D-C	-1.900	-24.076	20.276	
D-F	192.400	170.224	214.576	***
F-E	316.000	-338.176	-293.824	***
F-B	-207.467	-227.711	-187.222	***
F-C	-194.300	-216.476	-172.124	***
F-D	-192.400	-214.576	-170.224	***

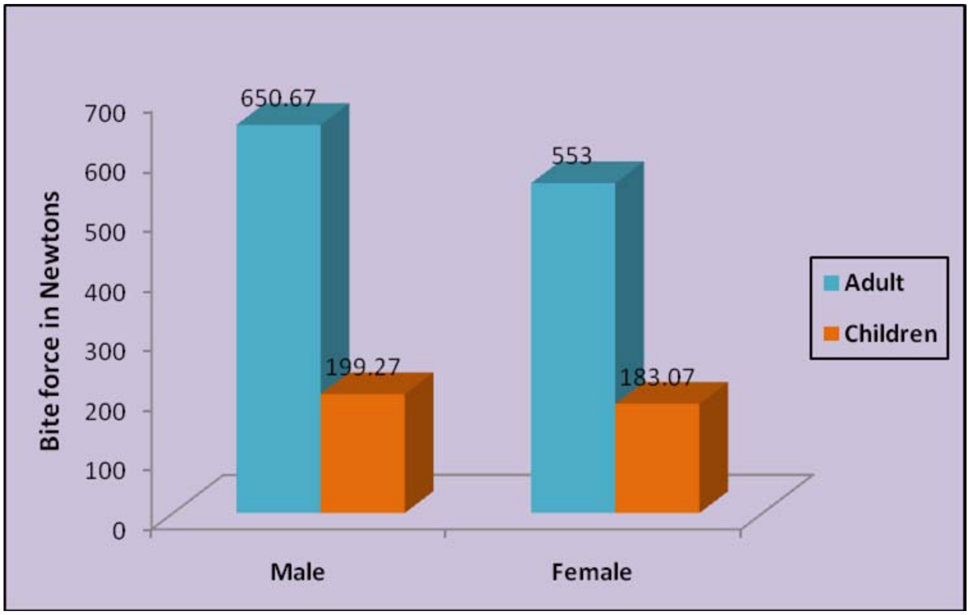
GRAPH 1

Comparison of Bite Force value in Children and Adults with Normal Occlusion



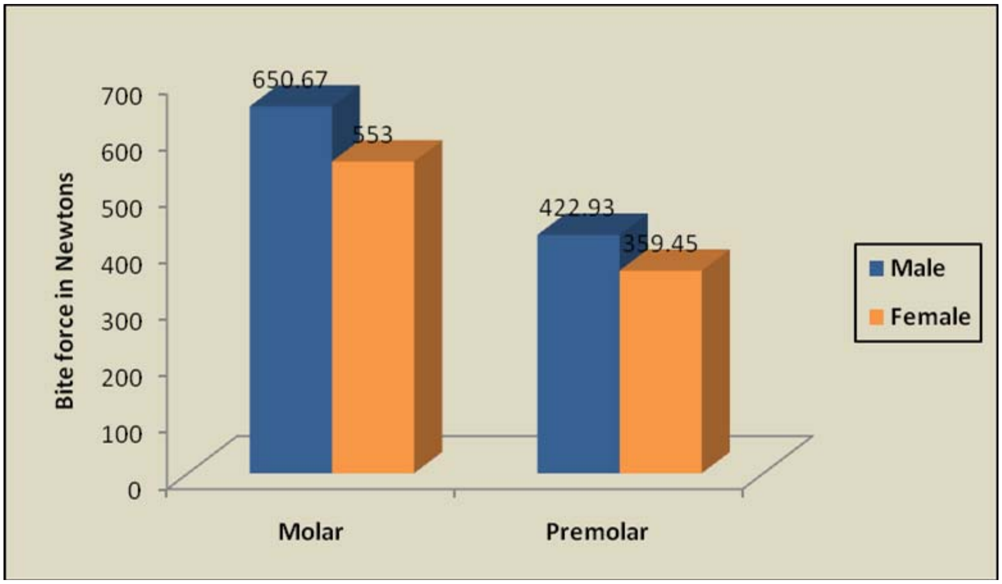
GRAPH 2

Comparison of Bite force in children and adults with normal occlusion in males and females



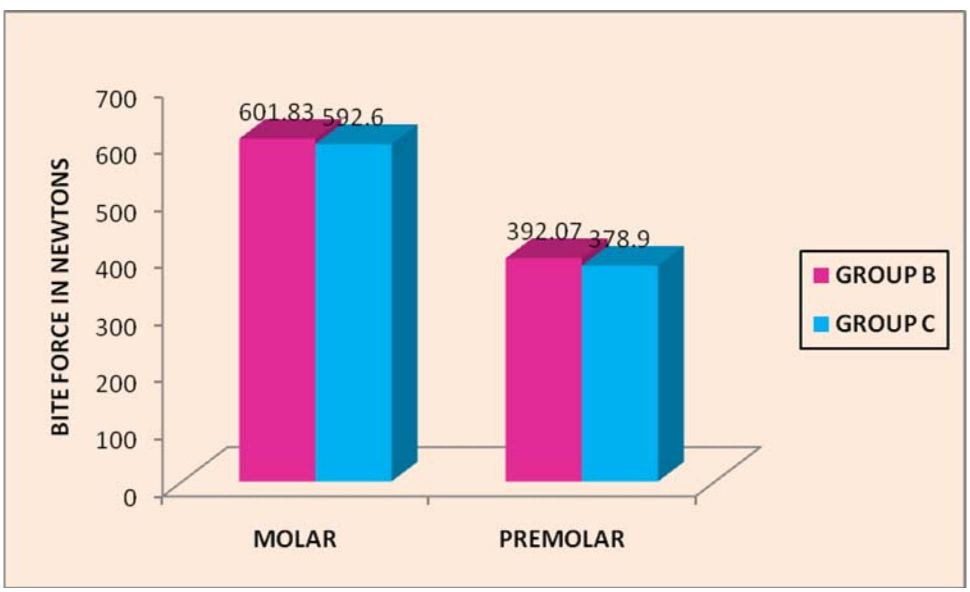
GRAPH-3

Comparison of Bite force in adults with normal occlusion to show gender difference



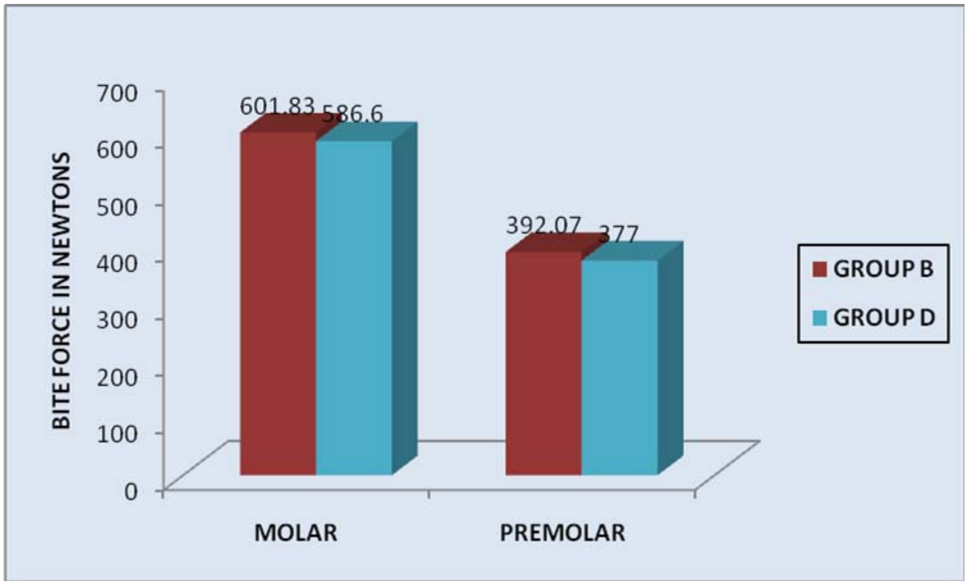
GRAPH-4

Column chart for comparison in adults between class I normal occlusion and Angle's class I malocclusion



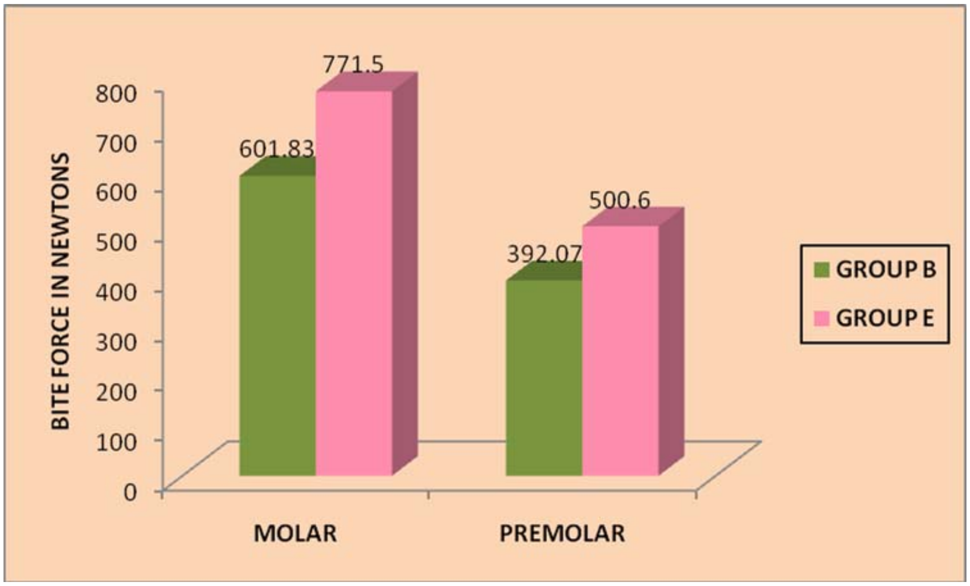
GRAPH-5

Column chart for comparison in adults between class I normal occlusion and skeletal class II malocclusion



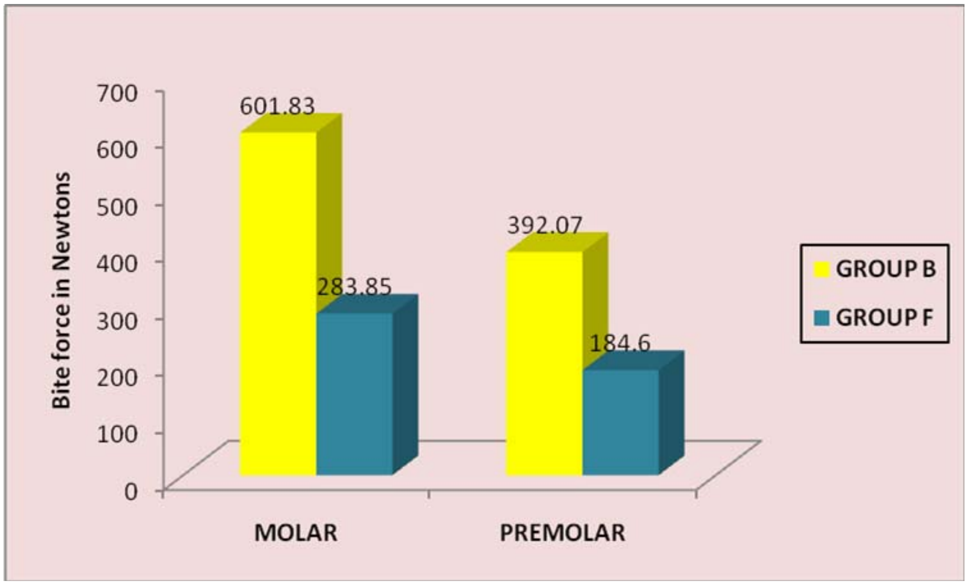
GRAPH-6

Column chart for comparison in adults between class I normal occlusion and hypodivergent facial morphology



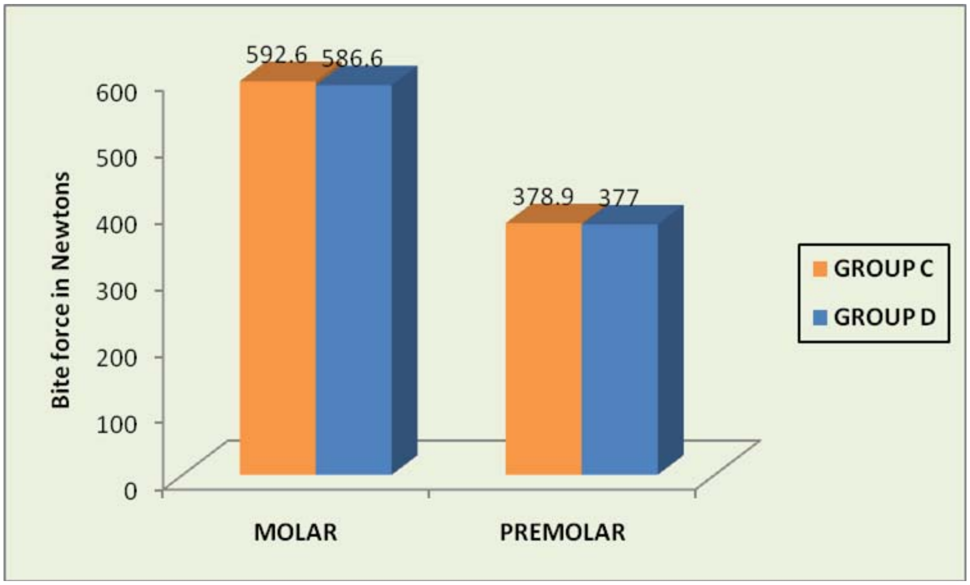
GRAPH-7

Column chart for comparison in adults between class I normal occlusion and hyperdivergent facial morphology



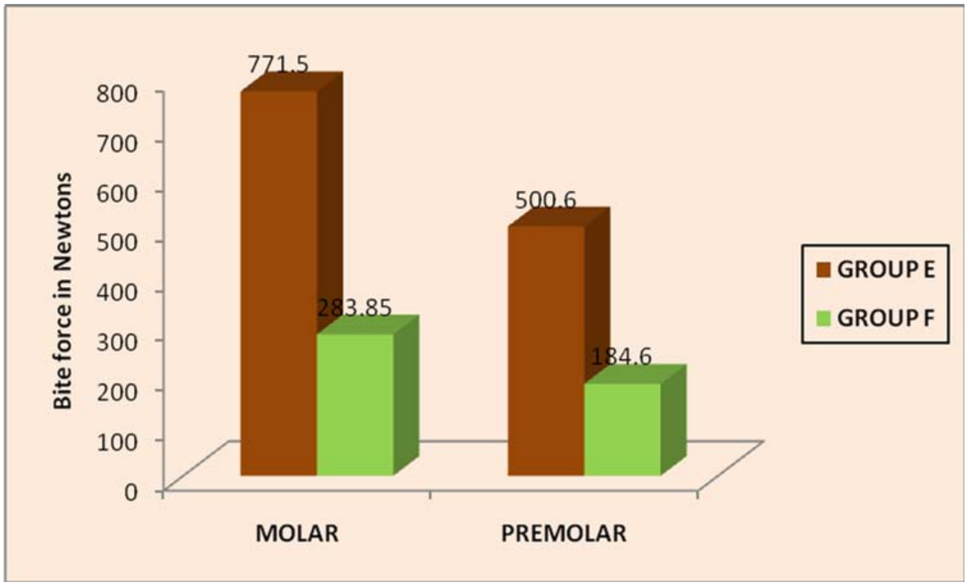
GRAPH-8

Column chart for comparison in adults between class I normal occlusion and Angle's class I malocclusion



GRAPH-9

Column chart for comparison in adults between hypodivergent facial morpholgy and hyperdivergent facial morphology



Discussion

DISCUSSION

Diagnosis and treatment planning in orthodontics involves the analyses of the masticatory muscles. The function of oral and facial muscles is a multi disciplinary act of complex nature. The design of the human facial skeleton is such that it serves the function of distributing masticatory forces without endangering the integrity of facial structures. Function of the masticatory muscles is also an important factor influencing dentofacial growth.

There is a definite interaction between size and function of the masticatory muscles and craniofacial morphology. Clinical and animal experiments have demonstrated the role of masticatory muscle function in normal and abnormal dentofacial development. The masticatory muscles also play an important role in the treatment of skeletal discrepancies by the use of functional orthopedic appliances. This is due to the tension they exert on the teeth and the bone structure, either by muscle contraction based on reflex mechanisms or through their viscoelastic properties[31]. The characteristics and the functional behavior of masticatory muscles are of great importance in the field of orthodontics.

Several studies have been conducted to learn the characteristic nature of these muscles and their relationship to their facial type. In depth knowledge of the muscles and their relationship will be of great importance in understanding the different facial forms and formulating an ideal treatment plan for these patients.

Masticatory muscle strength can be evaluated by different methods and is influenced by many variables. Masticatory muscle activity was assessed using Electromyography by **Ahlgren(1966)**[1], **Ingervall(1974)[23], Van Eijden(1990)[92]**, **Morales(2003)[47],**Ultrasound by **Bakke(1992)[4], Benington(1999)[6], Kiliaridis(1993)[31],** Computed Tomography by **Van Spronsen (1989)[85], Katsumata(2004)**, Magnetic Resonance Imaging by **Van Spronsen(1991)[86], Raadsheer(1996)[60],** and bite force measurement by **Ingervall(1978,1997)[26,27,28], Killiaridis(1993)[31], Stanley Braun(1995)[75], Bakke(2005)[36]**. Of all the above mentioned methods, recording the bite force is the most simple and noninvasive procedure which can be done as chair side procedure.

Maximum bite force is a useful indicator of the functional state of the masticatory system and the loading of the teeth[2]. Bite force is influenced by muscle efficiency and development of masticatory function. Maximum bite force increases with the number of teeth present. The number of occlusal tooth contacts is an important determinant for the maximally attainable bite force[39, 37]. Bite force magnitude depends on the size of the jaw muscles and the lever arm lengths of bite force and muscle forces, which in turn are influenced by craniofacial morphology.

This association is closest in the posterior region, which denotes that loss of molar support results in reduction of force.

Worner, Boos, and Losch[22] measured the bite force as early in **1938**. In Worner's device, the biting force was transmitted from a plunger to a liquid and registered on a pressure gauge. The equipment employed by Losch consisted of a sylphon bellows through which pressure was applied to a liquid and registered on a manometer. Many of the instruments were used for measuring oral forces but could not be applied for measurement on a single tooth. So, **Howell and Manly**[22] in **1948** introduced a bite element using electronic strain gauge which was 9mm wide and 6mm thick which was easy to operate.

Hagberg (1990)[20] recorded the bite force with one or two transducers placed between pairs of opposing teeth during clenching. Pressure sensitive sheets, thin force sensing resistors, and strain gauges were used by **Bakke (1992)**[4]**, Shinogaya (2000)**[72] **and Fernandes (2003)**[11] that did not disturb the dental occlusion and can be used between pairs of opposing teeth during clenching as a chair side procedure. A Bite force meter that consists of an electronic strain gauge with a digital indicator (photoplate-2,3) was used in this study since it was considered simple, very convenient, portable, resistant to deformation, and readings can be seen immediately on the indicator. Strain gauges were used by **Howell and Manly (1948)**[22]**, Floystrand et al (1982)**[13]**, Bakke et al (1990)**[3]**, Sonnesen et al (2005)**[36] for assessing the bite force. Strain gauges are simple and accurate readings can be recorded than other extensive equipments like pressure transducers and gnathodynamometers[2].

In this study, 140 subjects consisting of 30 children aged 7-11 years and 110 adults aged 17-25 years were evaluated for maximum voluntary bite force in permanent first molar and first premolar region. Lateral cephalograms were taken for all the subjects (photoplate 7, 8, 9) and they were hand traced. Based on certain cephalometric measurements (table 1, 2), the subjects were divided in to various groups. Bite force was measured using a bite force meter (photoplate 2,3) which consists of an electronic strain gauge and digital display indicator. Strain gauge was covered with putty silicone to prevent its deformation and subjects were asked to bite as hard as possible and readings were noted.

Children in the age group of 7-11 years with normal occlusion were selected to know the average bite force value before the onset of puberty. **Proffit et al (1983)**[57] found that difference in masticatory muscle strength occurs at puberty. Adults in the age group of 17-25 years were selected to measure in first permanent molar and first premolar region to avoid any regressional changes occurring in the dentition which may affect the bite force value. 30 adults with normal occlusion served as control group and their values were compared with adults having Angle's class I malocclusion, skeletal class II malocclusion, hypodivergent facial morphology and hyperdivergent facial morphology to assess the difference in bite force in malocclusions.

The separation of teeth during measurement of bite force was 15mm. **Manns et al (1979)**[42] and **Paphangkorait et al (1997)**[51] found that bite force levels increase with increased jaw opening up to 15-20mm of interincisal distance, which corresponds to the optimum length of the jaw elevator muscle sarcomeres and bite force decreases with further opening. This length tension relationship should be considered when assessing bite force with a bite force meter that increases the bite height and jaw separation.

The maximum bite force measured at the first molars and first premolars in adults with normal occlusion was compared to 20 adults with Angle's class I malocclusion and 20 adults with skeletal class II malocclusion to find out if there was any alteration in bite force in different sagittal relationships. The maximum bite force measured at the first molars and first premolars in adults with normal occlusion was again compared in 20 adults with hypodivergent and 20 adults with hyperdivergent facial morphology. Student t test and ANOVA was done to analyse the results statistically.

In this study, the average bite force recorded in children at the permanent first molars was 191.17N with boys having a value of 199.2N and in girls it was 183.07N. (Table 6,) This showed that there was no significant sex difference in bite force. The results were comparable with the study of **Braun et al (1996)**[77]**,** who studied that correlation of maximum bite force to gender was not found significant up to age 18. Studies done by **Tanner et al (1962)** showed that excretion of ketosteroids in post pubertal young men is related to the increase in muscle mass. Beyond age 16, muscle mass increases in males at a significantly greater rate than in females. Thus, continued muscle development could account for gender related bite force differences in the post pubertal population. The mean maximum bite force increased throughout growth and development.

In this study, Molar bite force in adult males with normal occlusion was 650.67N and in adult females it was 543.00N and bite force measured at the first premolars in adult males was 422.933 N and in females was 349.450 N (Table 8,graph 2) which a showed a statitistically significant difference between the two genders. This coincides with results of **Bakke et al (1990)**[3]**, Throckmorton et al (1995)**[81] **and Osborne et al (1993)**[49]**.** A positive correlation of bite force with gender was also established by **Dean et al (1992)**. A more posteriorly positioned transducer yields a greater bite force. This was most likely due to the mechanical lever system of the jaws.

In this study, molar bite force in adults with Angle's class I malocclusion was 592.60 N and premolar bite force of 378.90 N. There was no statistically significant difference in bite force values measured in adults with class I malocclusion and normal occlusion. (Table 9A, graph 4)

Molar bite force in adults with skeletal class II malocclusion was 586.60 N and premolar bite force of 377.00 N. There was no statistically significant difference in bite force values measured in adults with skeletal class II malocclusion and normal occlusion. (Table 9B, graph 5)

Malocclusions defined solely on the basis of molar and canine relationships have less influence on the level of bite force. **Sonnesen et al (2005)**[36] described that bite force does not vary between Angle malocclusion types. **Miralles et al (1991)** compared the EMG activity of class I, II, III malocclusion groups and found no differences at maximal clenching.

Relationships between weak muscles, malocclusion and hyperdivergence have been well established in adults by **Ringqvist(1973)**[65]**, Ingervall and Helkimo (1978)**[26]**, Proffit et al(1983)**[57,58]**, Bakke(2006)**[2] **and, Kayukawa(1992), Raadsheer et eal(1999)**[61]**, Benington et al(1999)**[6]**, Throckmorton et al(2000).**

In this study, there was a significant difference in bite force measured in low angle and high angle subjects. Subjects with hypodivergent facial morphology had a molar bite force of 771.50N and premolar bite force of 500.60N which is statistically significant and higher than the average bite force values (Table 9C, graph 6). **Ingervall and Helkimo (1978)**[26] found that higher bite forces correlated with a small cranial base flexure, a deeper upper face, a small anterior and a larger posterior facial height and a less divergent, broader face. **Ringqvist (1973)**[64, 65] found that there was a significant correlation between the size of type II fibers of masseter and bite force, but not between the size of type I and intermediate fibers. This suggested that primarily, type II fibers are designed for powerful biting efforts.

Subjects with hyperdivergent facial morphology had a molar bite force of 283.85 N and premolar bite force of 184.60N which is statistically significant and lower than the average bite force values. (Table 9D, graph 7) **Van Spronsen (1992)**[87] proposed that the lack of masticatory muscle strength in long faced children may be the result of poor working conditions for the muscles due to occlusal instability. This hypothesis is supported by the results of **Bakke (1992)**[4], who found a positive relationship between masticatory muscle strength during static and dynamic functions and the number of occlusal contacts. According to **Van Spronsen (1992)**[87], the masticatory muscles of long faced adults were characterized by disuse atrophy because the low muscle strength cannot be explained solely by the small cross sectional area of the muscles. This muscle atrophy was found to take place during the development of the long face morphology.

Rinqvist(1973)[64,65], **proffit et al(1983)**[57,58], **Kiliaridis et al (1993)**[31], **Braun et al(1996)**[77], **Ingervall (1997)**[27], **Raadsheer et al(1999)**[61], also studied the correlation between bite force and facial morphology and found that bite force is significantly higher in low angle subjects and lower in high angle subjects. **Proffit and Fields (1983)**[57,58] did not find any correlation between bite force and facial morphology in children and found that long face adults have less bite force than adults with normal occlusion . **Weijs (1986)**[97], **Van Spronsen (1989)**[85], **Raadsheer (1999)**[61], **Kiliaridis (1993)**[31], evaluated the correlation between cross sectional area of the mandibular muscles and bite force. **Van spronsen (1989)**[85] showed a positive correlation between bite force magnitude and cross sectional area of masseter muscle with CT and MRI. **Sasaki et al (1989)**[69], **Hannam and Wood (1989)**[18] **and Bakke (1992)**[4], found a positive correlation for both masseter and medial pterygoid muscles but no correlation between cross - sectional areas and muscle moment arms.

In children with long face morphology, Electromyographic studies done by **Ingervall et al (1974)**[23], **Ahlgren et al(1966)**[1] showed low levels of activity in the mandibular elevators and Studies by **Kiliaridis et al(1993)**[31] **and Ingervall et al (1997)**[28] showed less bite force at the molars and incisors.

Morales et al (2003) [47]found a significant correlation between skeletal divergences and bite forces in 7-13 year children.

Hence measurement of maximum bite force at the molars, premolars is a very simple, cost effective and time saving method for assessment of masticatory muscle strength and function than other invasive and time consuming procedures like EMG and ultrasound.

Summary & Conclusion

SUMMARY AND CONCLUSION

Summary

Maximum voluntary bite force was measured in 140 subjects consisting of 30 children and 110 adults. Bite force in adults was measured at the permanent first molar and first premolar region. Bite force in adults with Angle's class I malocclusion and skeletal class II malocclusion, those with hypodivergent and hyperdivergent facial morphology was compared with those of normal occlusion. Bite force was measured in children in permanent first molar to assess the normal values and to find gender difference.

- Molar bite force in adult males with normal occlusion was 650.67N and in adult females it was 543.00N and bite force measured at the first premolars in adult males was 422.933 N and in females was 349.450 N.
- There was significant gender difference in adult subjects.
- In children, the bite force at the permanent first molars was 191.17N with boys having a value of 199.2N and in girls it was 183.07N.
- There was no gender difference in bite force in children.
- Children had less bite force than adults suggesting that the maximum voluntary bite force increases during growth and development.

- Bite force values in subjects with angle's class I malocclusion and skeletal class II malocclusion compared with those of normal occlusion were not statistically significant.
- The maximum voluntary bite force in hypodivergent faces was 771.50 Newtons in molar and 500.60N in premolar region. In hyperdivergent faces it was 283.85 Newtons in molar and 184.60N in premolar which expounds that low angle subjects have a higher value than high angle subjects.
- Bite force was correlated with vertical facial morphology and it was observed to have a highly significant correlation with a p value of 0.001

Conclusion

The conclusions obtained in this study are,

1. There is significant difference in maximum voluntary bite force between children and adult measured at the permanent first molar region.
2. Children did not show any gender difference in bite force where as adults had a significant gender difference with males having a higher value than females.

3. There is no significant difference in bite force in adults with Angle's class I malocclusion and skeletal class II malocclusion.
4. Bite force varies with vertical facial morphology, with hypodivergent faces having a higher value than hyperdivergent faces.
5. Bite force meter can be used as a reliable diagnostic tool for assessing the bite force to evaluate the masticatory muscle strength and function.

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